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Discussion on the Influence of Mathematics Games on Students' Frustration Tolerance and Problem-Solving Skills

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Abstract: *This study used computer animation to present mathematic questions with digital geometry and spatial reasoning, allowing users to perform calculation through animation games and mitigate theirs frustration towards mathematics learning. Moreover, through the proposed game, this study analyzed the frustration tolerance of the users when using the game to solve the problems, their thinking and responding processes, and the influence of the game on their mathematics learning attitude. A questionnaire survey was conducted, and a total of 308 valid samples were retrieved. The data were analyzed using AMOS for the model's goodness of fit. The findings are as follows: (1) the students' game-playing attitude, frustration tolerance, and mathematics learning attitude have a significant effect on their problem-solving skills; (2) game-playing attitude has a significant and positive influence on frustration tolerance and mathematics learning attitude; and (3) the students' mathematics learning attitude can enhance their frustration tolerance level. The findings can serve as a reference for teachers in teaching introspection.*

Keywords: *Math and science animation; Math and science game; Frustration tolerance; Problem-solving skills.*

1. INTRODUCTION

In Taiwan, most parents only value their children's exam scores, and choose to neglect the learning process [4]. In an educational environment where results are valued yet the learning process is overlooked, learning is stressful for students. Students struggle for high exam marks, and the parents argue about the frequency of the General Scholastic Ability Test and the fairness of the scale. The quest for knowledge is not based on interest, but on exam scores. For students, learning is for the purpose of taking exams, but to not gain knowledge; thus, they commonly lack passion and genuine interest in learning. Even for the students in the higher education programs, they still lack the motivation and interest in learning, and often feel lost about the career planning [2]. Under those pressures, students tend to withdraw or choose avoidance when encountering challenges.

2. RESEARCH MOTIVATION

In the advent of the digital era, there are abundant and accessible learning resources [9]. Individuals can search for answers to the problems or issues in reality on the digital learning platforms. Computer operation, reading online information, or watching animated illustrations [11] can arouse learning motivation and allow learners to deliberate over important concepts or theories. The knowledge and skills gained from digital learning can be applied to the reality, and solve practical problems [10]. Thus, digital tools not only can disseminate knowledge, but also be used as supplementary learning tools for enhancing thinking capacity, sharpening problem-solving skills, and training critical or creative thinking skills.

This study aims to develop a user-friendly digital geometry and spatial reasoning game. The game design is not based on visual and sound effect, thus, the users will not feel intense or constrained, so that they can think rationally for problem-solving. In the process of geometry reasoning, the users can learn to solve problems and apply the learning to daily life.

The purpose of this study is to stimulate students' interest in learning geometry and mathematics, and enhance their problem-solving capability. After all, finding answers to problems is the purpose of education. Moreover, this study investigated the effect of students' frustration tolerance on their mathematics learning attitude.

3. LITERATURE REVIEW

3.1. Brain Games

Logical reasoning is a key element in learning; the abstractness in mathematics learning is the foundation of higher-order reasoning. The ability to integrate knowledge and perform logical thinking is essential in knowledge transformation. Many teachers in the United States have shifted the educational purpose from teaching-oriented to high-order thinking [26]. The quality of teaching could be improved if teachers can use games to cultivate students' logic and reasoning skills [12]. The training of logical thinking remains insufficient in elementary school curriculum. Logic and reasoning skills are important for students to think fast and make correct judgments when dealing with abstract learning scenarios that create a heavy cognitive load [12].

Chang (2008) [1] stated that brain games could make mathematics more interesting, and train students' logic and reasoning skills. The creative thinking ability cultivated by geometry reasoning can promote children's mathematics intelligence. If the students can apply mathematics in everyday life, they will develop interest in mathematics learning.

Faust, Ginno, Laherty, and Manuel (2001)[16] reported that about 10.02–10.75% improvement by students on questions that tested student of library recall an instruction reading assignment was replaced with a crossword puzzle. The game is a tool that allows students to have good time. Librarians should take advantage of a variety of teaching methods, in order to engage students so they achieve the goal about cognitive and affective learning outcomes [17].

3.2. Problem-Solving Skills

Li and Wang (2004) [2] pointed out that students like to use simple technology tools for learning discussions, from which they would be inspired. The discussions among the students and teachers could enhance the students' learning interests, and develop their problem-solving abilities.

Chang and Weng (2000)[14] proposed that students' problem-solving skills and scientific exploration processes depend on their level of capability. Those with higher capability tend to solve problems by reasoning and categorization, whereas those with lower capability adopt more direct approaches and think from the angle of different scientific exploration processes.

3.3. Frustration Tolerance

Lang and Fan (2009)[25] suggested that a student's frustration tolerance is affected by the socio-economic status and environment of their family. Students from a family headed by two parents and with a higher socio-economic status have higher frustration tolerance. Relatively speaking, students with higher frustration tolerance have better adaptability.

Chen (2008)[5] found that students' frustration tolerance level is related to their frustration in academic study. When encountering frustration in academic study, students will develop more negative emotions, such as anxiety or depression. Thus, developing students' frustration tolerance ability will reduce their level of stress and lead to better learning results.

3.4. Mathematics Learning Attitude

Tso, Chiang, Lu and Sun (2008)[23] proposed that Internet mathematics competitions can add fun to mathematics learning, and enhance students' motivation to learn mathematics, as well as mitigate learning-related stress. Thus, students would have a positive attitude towards learning mathematics and a sense of achievement.

The enjoyment of mathematics conclude the measure to which the student enjoys mathematics classes and the goal setting of itself. Finally, the value of mathematics refers to the beliefs that student holds is about their daily mathematics attitudes and later life [20].Many research studies have focused on the role of use ICT in the teaching and learning of mathematics. There is evidence that ICT has an all-around positive effect on mathematics achievement [19].

3.5. Game-Playing Attitude

Lai (2008)[3] suggested that collaborative mathematics games could enhance students' interest in learning mathematics, boost their confidence in learning, invoke the spirit of taking the initiative to

explore things, encourage interactive learning among students, and enhance students' mathematics learning attitude through the process of sharing and discussing procedures for solving mathematics questions.

Students who have more positive attitudes towards mathematics courses have better attitude towards educational computer games. Thus, educational computer games can be used an a supplementary tool in teaching [21].

4. RESEARCH METHOD

4.1. Research Tool, Subjects, and Scope

A questionnaire was designed based on a Likert 5-point scale. The data collected were analyzed using IBM SPSS Amos 19. By purposive sampling, this study distributed the questionnaires to the senior grade elementary school students who visited the exhibition booth of the researcher at the Science 168 Exhibition. During the exhibition period, there were about 1,000 visitors to the exhibition booth every day.

4.2. Research Design and Questionnaire Distribution

A computer animation game was designed to analyze the influence of problem-solving skills and frustration tolerance of the students on their mathematics learning attitude (Figure 1. and Figure 2.).

A total of 350 questionnaires were distributed, and 308 samples were retrieved, with a valid return rate of 85%. The respondents were students who attended the Science 168 Exhibition.

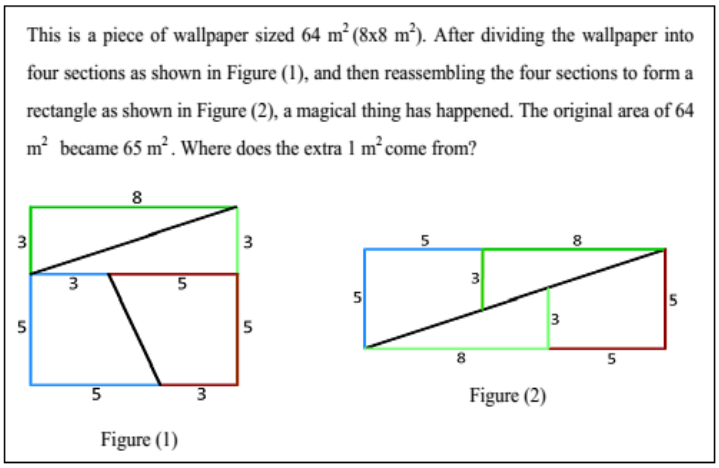

Fig1. *Scene 1 of the game*

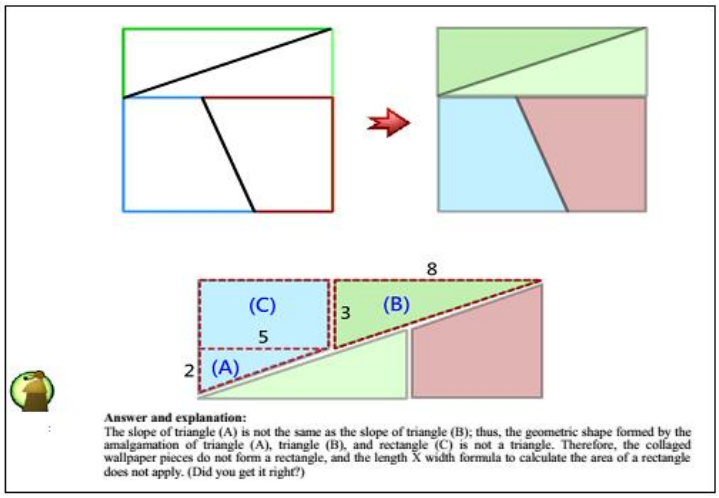

Fig2. *Screenshot 2 of the brain training game*

Figure3. Shows the research framework of this study. The hypothesis argues that the students' frustration tolerance and mathematics learning attitude make a difference on students' problem-solving skills.

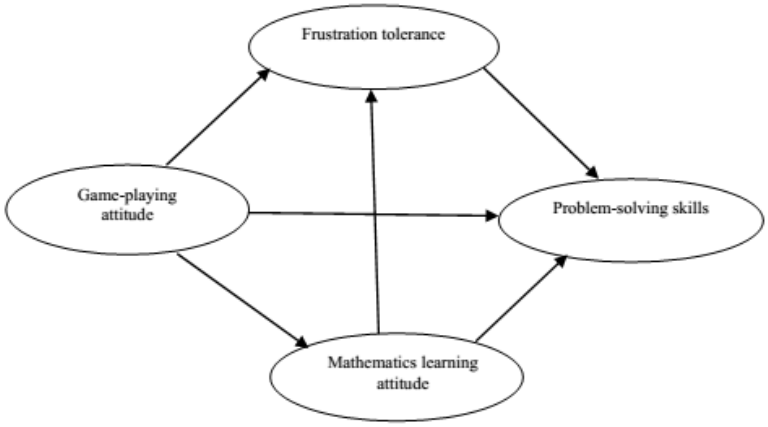

Fig3. *Research framework*

5. Questionnaire Design, and Reliability and Validity Analyses

The scale for frustration tolerance was modified from Lin and Huang (2011)[22] and Clifford (1988)[15]. The scale for problem-solving skills was modified from Wu (1996)[7] and Chan and Wu (2007)[8]. The scale for mathematics learning attitude was modified from Wang (2005). The scale for game-playing attitude was modified from Tseng (2009) [18].

The reliability coefficient of the dimension of frustration tolerance was .832 that of problem-solving skills was .893, that of mathematics learning attitude was .769, and that of game-playing attitude was .899, which all indicated good reliability. In terms of the validity, as the scales were all modified from previously established scales, thus they all had good validity.

6. Results

The structural equation modeling (SEM) was performed using AMOS to analyze the correlation among frustration tolerance, problem-solving skills, mathematics learning attitude, and game-playing attitude. Then, the goodness of fit of the model and the relationships among the dimensions were examined.

A structural model with linear relations is shown in Figure 4. The purpose of the model's overall goodness-of-fit test was to examine the model and observe the data's overall goodness-of-fit. A model with a greater goodness-of-fit value would have greater usability. The general standard for a model with adequate goodness-of-fit is an RMR value smaller than 0.05, a GFI value greater than 0.90, an AGFI value greater than 0.90, and a PGFI value greater than 0.50.

Table1. *Overall goodness of fit of the structural model*

Goodness-of-Fit Index	$\chi 2$ test	$\chi 2$/df	GFI	AGFI	PGFI	RMSEA	NFI	CFI
Suggested Value	p>.05	<3.0	>0.9	>0.9	>0.5	<0.08	>0.9	>0.9
Research Model	$\chi 2$=253.514, p=0.000	1.736	0.921	0.897	.708	0.049	0.923	0.965

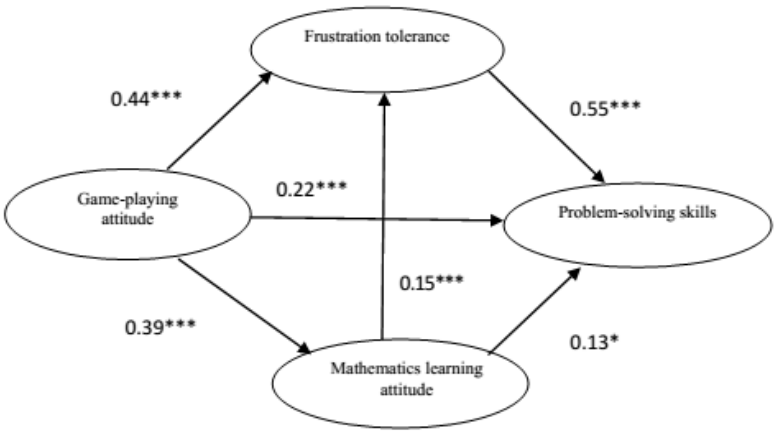

Fig4. *Research model*

Table2. *Path coefficients between dimensions*

Path			Standard Coefficient	P Value
Frustration tolerance	<---	Game-playing attitude (β_1)	.44***	.000
Mathematics Learning attitude	<---	Game-playing attitude (β_2)	.39***	.000
Problem-solving skills	<---	Game-playing attitude (β_3)	.22***	.000
Problem-solving skills	<---	Frustration tolerance (β_4)	.55***	.000
Frustration tolerance	<---	Mathematics learning attitude (β_5)	.15***	.000
Problem-solving skills	<---	Mathematics learning attitude (β_6)	.13*	.045

As seen above, the students' game-playing attitude, frustration tolerance, and mathematic learning attitude had a significant influence on their problem solving skills. The students' game-playing attitude and frustration tolerance had a significant influence on their mathematics learning attitude. Their mathematics learning attitude could enhance their frustration tolerance level. The direct effect of students' game-playing attitude on problem solving skills was 0.22. Nevertheless, the indirect effect of students' game-playing attitude on problem solving skills was 0.3149. Frustration tolerance and mathematics learning attitude were the mediating variables. The total effect was 0.5349. The results showed that the spirit of trial and error had a strong correlation with students' mathematics learning attitude. Also, how the students tolerated frustration when encountering difficulties indirectly enhanced their problem-solving skills.

According to this study, the different effects of students' game-playing attitude on mathematics learning attitude affected their frustration tolerance. That is, students who were more interested in learning mathematics would be more willing to put effort into finding solutions to problems. However, students who were less willing to learn mathematics would be less willing to spend time solving problems. Instead of taking the initiative to find solutions, they would be more likely to give up when encountering difficulties.

7. CONCLUSION AND SUGGESTIONS

Digital games have the advantages of providing life experiences, fun, and immediacy, all of which can trigger the learners' motivation to learn, enhance their learning effectiveness, and cultivate their problem solving, critical thinking, and creative thinking skills.

This study found that students' game-playing attitude, frustration tolerance, and mathematics learning attitude affect their problem solving skills. Moreover, their game-playing attitude and frustration tolerance influence their mathematics learning attitude. Their mathematics learning attitude affects their frustration tolerance. In other words, students' attitudes and responses when encountering difficulties affect their behaviors.

Future studies can continue to investigate the influence of frustration tolerance on other factors.

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